TITLE OF THE INVENTION

SCENE CHANGE DETECTOR AND METHOD THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 2002-39579, filed July 9, 2002, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to a scene change detector and a method thereof, and more particularly, to a scene change detector and a method of detecting a scene change between motion pictures by using co-relation information between histograms with respect to color signals of chroma or luminance.

2. Description of the Related Art

[0003] Generally, a scene change represents that a motion picture changes from one scene to another scene in consecutive scenes (screen pictures) after the one scene is finished. The scene change is generally divided into several modes: a fade-out and fade-in mode that a certain scene is gradually disappeared and another scene is slowly shown, an overlap mode that two certain scenes are overlapped slowly from different directions for a certain time interval, and a simple scene change mode.

[0004] A scene change detector is an apparatus detecting the scene change of the motion picture and can be applied to digital TVs, a computer-based image processing system, and an MPEG signal processing system.

[0005] For instance, by adapting scene change detection of the scene change detector to improve a contrast of an image for a digital TV and the like, flickering or panning phenomena occurring on the contrast of the image can be appropriately coped with.

[0006] For the MPEG signal processing system, an interframe coding technique using motion prediction and compensation is adapted to compress data that is closely related on an axis of time. When the scene change occurs between scenes of the motion picture, a frequency of redundancy of same image data is low, thereby causing an amount of the data to be increased.

Therefore, when the MPEG signal processing system is performed without reflecting special picture effects like the scene change, a rate of bit utilization is lowered and a quality of the motion picture deteriorates, thus it is necessary to perform the scene change detection before signal processing of the motion picture.

[0007] There have been several techniques developed for the scene change detector and a method thereof to detect the scene change between scenes of the motion picture.

[0008] For example, US Patent No. 6,049,363 entitled "Object detection method and system for scene change analysis in TV and IR data" discloses a pixel difference method based on information of edges of two frames for scene change detection.

[0009] US Patent No. 5,032,905 entitled "Accurate detection of a drastic change between successive pictures" discloses a frame difference method applied between two frames for scene change detection.

[0010] US patent No. 5,835,663 entitled "Apparatus for recording image data representative of cuts in a video signal" discloses another method of a scene change detection in that a histogram with respect to a chroma color signal of each sub block is obtained after two frames are divided into sub blocks, wherein correlation information is calculated to be statistically processed through a total comparison of the sub blocks.

[0011] These conventional scene change detectors and the methods thereof as described above, use algorithms based on motion vectors or a frame difference method. These algorithms have disadvantages of a slow processing speed due to complexities of architectures thereof. Therefore, these methods are not so effective when motion information in image frames is not very important, like in cases of improving the contrast or color of images.

[0012] Moreover, the conventional scene change detectors and the methods thereof cannot provide an effective method to improve the quality of the moving picture by detecting TI ("Title Insertion"), that is a subtitle displayed on the moving picture, or PIP ("Picture in Picture"), that is, another picture displayed in the moving picture to be considered together with the scene change.

SUMMARY OF THE INVENTION

[0013] The present invention has been made to overcome the above and/ other problems of

the related art. Accordingly, it is the aspect of the present invention to provide a scene change detector and a method thereof which can be used when motion information in an image frame is not significant such as a case of improving a contrast of a picture in the image frame.

[0014] Another aspect of the present invention is to provide a scene change detector and method capable of improving a quality of a picture when there is TI (Title Insertion) or PIP (Picture In Picture) by considering a scene change.

[0015] Additional aspects and advantages of the invention will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0016] A scene change detector according to an aspect of the present invention includes first and second histogram detection units individually calculating first and second histograms with respect to predetermined input first and second color signals, a cross correlation coefficient calculation unit calculating a correlation value between the first and second histograms calculated from the first and the second histogram detection units respectively, and a decision unit outputting a scene change signal by comparing the correlation value with a predetermined threshold.

[0017] According to another aspect of the invention, the scene change detector further includes first and second frame buffers storing two image frame data to detect the scene change, respectively, and first and second color space conversion units converting the image frame data stored in the first and the second frame buffers into the predetermined first and second color signals and outputting the predetermined first and second color signals to the first and the second histogram detection units, respectively.

[0018] The predetermined first and second color signals are luminance color signals or chroma color signals. It is possible that the first and the second histogram detection units quantize the respective ones of the input color signals to a predetermined signal band, calculate the number of pixels having the same value of the quantized input color signal with respect to all pixels in a predetermined frame, and calculate the first and the second histograms by standardizing the calculated number. It is possible that the decision unit outputs the scene change signal when the correlation value is less than the predetermined threshold which is in a range of 0.9 to 0.95.

[0019] According to another aspect of the invention, a scene change detector includes first and second histogram detection units individually calculating histograms with respect to predetermined input first and second color signals, first and second average/maximum calculation units individually calculating average values and maximum values from the first and the second histograms calculated at the first and the second histogram detection units, respectively, a comparison unit outputting an average signal by comparing a first difference between the first and the second average values calculated from the first and the second average/maximum calculation units with a predetermined first threshold, respectively, and a maximum signal by comparing a second difference between the first and the second maximum values calculated from the first and the second average/maximum calculation units with a predetermined second threshold, first and second filters individually outputting first and second histograms having suppressed respective peak values by filtering the first and the second histograms, a cross correlation coefficient calculation unit calculating a correlation value between the filtered first and second histograms, and a decision unit outputting a scene change signal by comparing the correlation value with a predetermined third threshold and a TI signal and a PIP signal based on the scene change signal and the average signal and the maximum signal output from the comparison unit .

[0020] It is possible that the scene change detector further includes first and second frame buffers individually storing two image frame data to detect the scene change signal, and first and second color space conversion units to convert the image frame data stored in the first and the second frame buffers into the predetermined first and the second color signals and output the converted first and the second color signals to the first and the second histogram detection units, respectively.

[0021] It is possible that the predetermined first and the second color signals are luminance color signals or chroma color signals.

[0022] It is possible that the first and the second histogram detection units quantize the respective input color signals to a predetermined signal band, calculate the number of pixels having the same value of quantized color signal from the quantized input color signals with respect to all pixels in a predetermined frame, and calculate the first and the second histograms by standardizing the calculated number, respectively.

[0023] It is possible that the decision unit outputs the scene change signal when the

correlation value is less than the predetermined third threshold which is in a range of 0.9 to 0.95.

[0024] It is possible that the comparison unit outputs the average signal when the difference between the first and the second average values are greater than the predetermined first threshold, and outputs the maximum signal when the difference between the first and the second maximum values are greater than the second threshold.

[0025] Furthermore, it is possible that the decision unit receives the average signal and the maximum signal, and outputs the TI signal and the PIP signal when the scene change signal is greater than the predetermined first threshold.

[0026] According to another aspect of the invention, a method of scene detecting includes calculating first and second histograms with respect to predetermined input first and second color signals, calculating a correlation value between the first and the second histograms, and outputting a scene change signal when the correlation value is less than a predetermined threshold.

[0027] It is possible that the method of scene detecting further includes individually storing two image frame data to detect the scene change signal and converting the image frame data into the predetermined first and second color signals, respectively.

[0028] According to another aspect of the invention, a method of scene detecting includes individually calculating first and second histograms with respect to input predetermined first and second color signals, calculating first and second average values and first and second maximum values from the first and the second histograms, outputting an average signal when a first difference between the calculated first and second average values is greater than a predetermined first threshold, and outputting a maximum signal when a second difference between the first and the second maximum values is greater than a predetermined second threshold, filtering the first and the second histograms to limit peak values and individually output the filtered first and second histograms, calculating a correlation value between the filtered first and second histograms, outputting a scene change signal when the correlation value is less than a predetermined third threshold, inputting the average signal and the maximum signal, and outputting a TI signal or a PIP signal when the correlation value is greater than the predetermined third threshold.

[0029] It is possible that the method of scene detecting of the present invention further includes individually storing two image frame data to detect the scene change signal and converting the image frame data into the predetermined first and second color signals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the preferred embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a block diagram showing a scene change detector according to an embodiment of the present invention;

FIG. 2 is a flow chart showing an operation method of the scene change detector of FIG. 1;

FIGS. 3A and 3B are views showing histograms generated in the scene change detector of FIG. 1;

FIG. 4 is a block diagram showing a scene change detector according to another embodiment of the present invention; and

FIGS. 5A and 5B are views showing histograms generated in the scene change detector of FIG. 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Reference will now be made in detail to the present preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described in order to explain the present invention by referring to the figures.

[0032] Hereinbelow, the present invention will be described in greater detail by referring to the appended drawings.

[0033] FIG. 1 is a block diagram showing a scene change detector according to an embodiment of the present invention.

[0034] The scene change detector includes a first frame buffer 100, a first color space conversion unit 102, a first histogram detection unit 104, a second frame buffer 110, a second color space conversion unit 112, a second histogram detection unit 114, a cross correlation

coefficient calculator 120, and a decision unit 130.

[0035] Referring to FIG. 1, the first frame buffer and the second frame buffer 100 and 110 individually store two image frame data having a predetermined temporal interval to detect a scene change from input video stream data. The first and second color space conversion units 102 and 112 individually convert respective color spaces of the image frame data stored in the first and the second frame buffers 100 and 110 into respective color signals. The first and the second histogram detection units 104 and 114 individually calculate first and second histograms from the color signals converted at the first and the second color space conversion unit 102 and 112.

[0036] The cross correlation coefficient calculator 120 calculates a correlation value C between the calculated first and second histograms, and the decision unit 130 compares the calculated correlation value C with a predetermined threshold and outputs a scene change signal.

[0037] FIG. 2 is a flow chart showing an operation method of the scene change detector of FIG. 1. Referring to FIG. 2, two image frame data having a predetermined temporal interval are respectively stored into the first and the second frame buffers 100 and 110 to detect a scene change from input video stream data in operation S150. The color spaces of the image frame data stored in the first and the second frame buffers 100 and 110 are converted at the first and the second color space conversion units 102 and 112 into chroma (or luminance) color signals in operation S152. In other words, the frame image data stored into the first and the second frame buffers 100 and 102 can have the color spaces, such as RGB, YIQ, YUV, YcbCr, or HLS based on a utility environment. These color spaces are converted into chroma (or luminance) color signals by using appropriate equations. For example, a calculation of the chroma (or luminance) color signal from an RGB color signal can be operated using the following equation 1.

Equation 1

$$Y = a \cdot R + b \cdot G + c \cdot B$$
$$S = \frac{Max[R,G,B] - Min[R,G,B]}{Max[R,G,B]}$$

Here, a, b, and c are conversion coefficients. For reference, according to the recommendation 601-1 of CCIR (International Radio Consultative Committee), a = 0.29900, b = 0.58700 and c =

0.1140. They are typical conversion coefficients used for JPEG compressing.

[0038] The first and the second histogram detection units 104 and 114 individually calculate the histograms from the chroma (or luminance) color signals converted at the first and the second color space conversion units 102 and 112 in operation S154 . At this time, one of the histograms calculated at the first histogram calculation unit 104 is a first histogram, and the other one of the histograms calculated at the second histogram calculation unit 114 is a second histogram. The method of calculating the first and the second histograms is as follows. The chroma (or luminance) color signals converted from the respective color spaces by the first and the second color space conversion units 102 and 112 are quantized to a predetermined signal band, such as 0~100 scales, 0~127 scales, or 0~255 scales, and each histogram is calculated to count the number of values having the same value with respect to a selected local window or entire pixels of an image frame or field. After a maximum value is searched in the histogram, the histogram is calculated by normalizing to allow the maximum value to have a certain value (for example, 100).

[0039] FIGS. 3A and 3B are views of the first and the second histograms calculated based on the above method. The shown histograms have the signal band of 0~255 and the maximum value of 100. In other words, an axis X is the signal band of 0~255, and an axis Y corresponding to each axis X is a counted value of the number of the pixels having the same value.

[0040] The cross correlation coefficient calculation unit 120 calculates the correlation value C by using the following equation between the first histogram calculated at the first histogram calculation unit 104 and the second histogram calculated at the second histogram calculation unit 114 in operation S156.

Equation 2

$$C = \sum \frac{(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{\forall_i} (x_i - \bar{x})^2} \sqrt{\sum_{\forall_i} (y_i - \bar{y})^2}}$$

Here, x_i is a predetermined value on the axis X of the first histogram calculated at the first histogram calculation unit 104, and y_i is a predetermined value on the axis X of the second histogram calculated at the second histogram calculation unit 114. $\bar{x}$ is an average value of

individual histogram counters of the first histogram, and $\bar{y}$ is an average value of individual histogram counters of the second histogram.

[0041] The correlation value C calculated by the equation 2 has a value between –1 and 1. When the first histogram is orthogonal to the second histograms, the correlation value C is –1. When a correlation degree between the first histogram and the second histogram becomes stronger, then the correlation value C is close to 1. When the correlation value C is 1, it is determined that the first histogram and the second histogram are the same.

[0042] The decision unit 130 creates a scene change signal C_{sc} by comparing the correlation value C calculated at the equation 2 with the predetermined threshold. In other words, when the correlation value C is less than the predetermined threshold, it can be regarded that the scene change is generated. An experimentally calculated threshold is 0.9 to 0.95. Therefore, when the correlation value C is less than 0.9 to 0.95, it is determined that there exists the scene change, thus the scene change signal C_{sc} is output as 1. When the correlation value C is greater than 0.9 to 0.95, the scene change signal C_{sc} is 0.

[0043] As described so far, even when there is a movement in the image frame after detecting the scene change by using correlation information between chroma (or luminance) histograms without using motion information, it is not determined that there exists the scene change.

[0044] FIG. 4 is a block diagram showing another scene change detector according to another embodiment of the present invention. Referring to the block diagram of FIG. 4, the scene change detector includes a first frame buffer 200, a first color space conversion unit 202, a first histogram detection unit 204, a first filter 206, a first average/maximum calculation unit 208, a second frame buffer 210, a second color space conversion unit 212, a second histogram detection unit 214, a second filter 216, a second average/maximum calculation unit 218, a cross correlation coefficient calculation unit 220, a comparison unit 222, and a decision unit 230.

[0045] As shown in the block diagram of FIG. 4, the scene change detector has more additional blocks, such as the first and the second filters 206 and 216, the first and the second average/maximum calculation units 208 and 218, and the comparison unit 222 than those of the scene change detector of FIG. 1. These additional blocks are used to detect mainly a picture-in-picture (PIP) signal or a title insertion (TI) signal.

[0046] Respective functions of the first and the second frame buffers 200 and 210, the first and the second color space conversion units 202 and 212, the first and the second histogram detection units 204 and 214, and the cross correlation coefficient calculation unit 220 are the same as those of the scene change detector of FIG. 1. Therefore, hereinbelow, functions of the additional blocks will be described.

[0047] The first and the second average/maximum calculation units 208 and 218 individually calculate an average value and a maximum value with respect to first and second histograms calculated at the first and the second histogram detection units 204 and 214. The average value and the maximum value calculated from the first histogram at the first average/maximum calculation unit 208 are a first average value and a first maximum value, respectively, and the average value and the maximum value calculated from the second histogram at the second average/maximum calculation unit 208 are a second average value and a second maximum value, respectively.

[0048] The first and the second average values and the first and the second maximum values calculated at the first and the second average/maximum calculation units 208 and 218 are transmitted to the comparison unit 222. The comparison unit 222 calculates an average signal C_{mean} and a maximum signal C_{max} based on the following equations.

Equation 3

$$\Delta S_{\max} = | S_{\max}(T-\Delta T) - S_{\max}(T) |$$
$$, if \;\; \Delta S_{\max} < Th1 \;\; then \;\; C_{\max} = 0 \;\; , else \;\; C_{\max} = 1$$

Equation 4

$$\Delta S_{mean} = | S_{mean}(T-\Delta T) - S_{mean}(T) |$$
$$, if \;\; \Delta S_{mean} < Th2 \;\; then \;\; C_{mean} = 0 \;\; , else \;\; C_{mean} = 1$$

Here, ΔT is a predetermined temporal interval, and thus $S_{\max}(T-\Delta T)$ and $S_{\max}(T)$ are the maximum values of the first and the second histograms, respectively. The case of the average values of the first and the second histograms is the same as described above.

[0049] The average signal C_{mean} and the maximum signal C_{max} calculated at the comparison unit 230 are transmitted to the decision unit 230.

[0050] In the meantime, the first and the second filters 206 and 216 reduce a peak value of the respective histograms formed by the TI signal or the PIP signal by using a linear or a non-linear filter. For example, FIG. 5A shows a histogram formed by the TI or PIP signal, and FIG. 5B shows another histogram formed by the signals passing through the first filter 206 or the second filter 216. As shown in FIGS. 5A and 5B, the peak value of the signals is limited when the signals pass through the first and the second filters 206 and 216. Using the first and the second filters 206 and 216 limiting the peak value occurring due to the PIP or TI signal, even when the PIP and TI signals are generated, the scene change signal Csc is prevented from being unconditionally output.

[0051] The first and the second filters 206 and 216 are a linear low pass filter or a non-linear medial filter.

[0052] The following equation is an example of an output histogram value with respect to an input histogram value calculated by using a 5-Tab median filter.

Equation 5

$$F_{out}(i) = Median[F_{input}(i-2), F_{input}(i-1), F_{input}(i), F_{input}(i+1), F_{input}(i+2)]$$

Here, $F_{input}(i)$ is the input histogram value, and $F_{out}(i)$ is the output histogram value. A median operator is a filtering method to take a medium value by rearranging given histogram values by their magnitudes. Once a histogram is finished its filtering, the maximum value is set, and the maximum value is standardized to a predetermined value (for example, 100).

[0053] The standardized histogram is transmitted to the cross correlation coefficient calculation unit 220. The cross correlation coefficient calculation unit 220 calculates the correlation value C by using the equation 2 explained above. The calculated correlation value C is transmitted to the decision unit 230.

[0054] The decision unit 230 creates the scene change signal Csc and the PIP (picture in picture)/TI (title insertion) signals CTI/P based on the following signal by using the correlation value C, the average signal C_{mean} and the maximum signal C_{max}.

Equation 6

$$If \quad (C \leq Th3) \quad then C_{SC} = 1, \quad else \quad C_{SC} = 0$$
$$If \quad ((C_{mean} == 1 \quad or \quad C_{\max} == 1) \quad AND \quad C > Th3) \quad then \quad C_{TI/P} = 1, \quad else \quad C_{TI/P} = 0$$

[0055] In other words, when the correlation value C is less than a threshold, it is a case of a general scene change. In this case, the scene change signal Csc is output as 1. When $C_{\max}$ or C_{mean} is 1, there is a significant change in preceding and following images, and at the same time, the correlation value C is greater than the threshold, then it is determined that the TI or PIP exists.

[0056] As described so far, since the fact that the scene change is a general change or it is caused by the TI or PIP can be detected, an improvement of a quality of a picture can be effectively performed by using the above information for the improvement of contrast of an image signal to appropriately cope with the above problems.

[0057] According to the present invention, the scene change unrelated to the movement in the image frame can be detected by using correlation information between histograms of chroma or luminance color signal. Moreover, the quality of the picture can be more effectively improved since the scene change by the TI or PIP and the general scene change can be separated from each other.

[0058] Although the preferred embodiments of the present invention have been described, it will be understood by those skilled in the art that the present invention should not be limited to the described preferred embodiments, but various exchanges and modifications can be made within the spirit and the scope of the present invention. Accordingly, the scope of the present invention is not limited within the described range but the following claims and their equivalents.